

Cooperative Communication In Near Field Magnetic Induction Communication Systems

A thesis submitted in fulfilment of the
requirements for the award of the degree

Doctor of Philosophy

from

UNIVERSITY OF TECHNOLOGY, SYDNEY

by

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January 2012

SCHOOL OF COMPUTING AND COMMUNICATIONS
CENTRE FOR REAL TIME INFORMATION NETWORKS

Abstract

Near-Field Magnetic Induction Communication (NFMIC) is a relatively new technology which has been proposed for short-range applications such as body-area networks. Since it uses a rapidly-decaying magnetic near-field instead of an electromagnetic wave as the signal transmission mechanism, it is ideal for situations in which limited transmission range is actually an advantage, such as where minimising inter-network interference or avoiding location disclosure are considered important.

To date, little work has been done on multihop techniques specifically designed for NFMIC systems. Most existing applications, such as Radio Frequency Identification (RFID) and Near Field Communication (NFC) are strictly point-to-point. However, when each network node only needs to transmit occasionally, multihop relaying techniques have the potential to significantly reduce power consumption and overall levels of magnetic field egress. Cooperative retransmission strategies, where network nodes that are neither a transmission source nor sink can participate in relaying of frames at the physical layer, have been proposed as a solution for range-extension of conventional electromagnetic/radiofrequency networks. This thesis aims to propose, analyse and simulate a variety of strategies for cooperative relaying which are appropriate for the specific needs of multihop NFMIC networks.

A link budget model for NFMIC is firstly developed and thoroughly analysed, for a variety of non-ideal channel conditions. Three relaying strategies are then proposed and evaluated using the link-budget model under a variety of channel conditions, varying from near-ideal to the pathological case, and a wide variety of source, des-

mination and relay node placement configurations. Simulation results are used to identify the key factors which govern the performance of each technique and the conditions under which throughput can be maximised. A new link metric, which accurately captures these factors, is proposed and its benefits demonstrated through simulation. Finally, a number of opportunities for future study are identified.

Statement of Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signed

Mehrnoush Masihpour

January, 2012

Dedication and Acknowledgments

To my beloved husband and my special parents:

Walking with you, through the journey of life has given me strength. Without you, my life would fall apart.

Mehdi, you are everything for me, without your love and understanding I would not be able to make it.

Mom, you have given me so much, you taught me to be strong and to pursue my dreams and never give up.

Daddy, you always told me to “never surrender”. I think I have learnt my lesson . . .

Acknowledgments:

This thesis would not have been fulfilled without the guidance and the help of several individuals who contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost I offer my sincerest gratitude to my principal supervisor, Dr Mehran Abolhasan, who has supported me throughout my thesis with his patience and knowledge whilst allowing me to work in my own way. His sage advice, and insightful criticisms helped the writing of this thesis in countless ways. I attribute the level of my PhD degree to his encouragement and effort and without him this thesis would not have been completed.

I am truly indebted and thankful to my previous principal supervisor and my external supervisor, Associate Professor Dr Johnson Agbinya, for his invaluable guidance and support throughout my studies. It has been an honour for me to work with him since the beginning of my research study. He patiently and continuously assisted me in my research. He has not been only a great advisor, but also an encouraging and motivating friend.

It gives me great pleasure in acknowledging the support and help of my co-supervisor Dr. Daniel Franklin, whose perpetual energy and enthusiasm in research had inspired me. Besides, he was always accessible and willing to help me. I would like to thank him for his immense contribution to this thesis and his wise advices. I was also delighted to work with my co-supervisor, Professor Robin Braun. His technical knowledge and world class research expertise have been a great help in this thesis.

I also wish to express sincere appreciation to the Faculty of Engineering and Information Technology (FEIT), University of Technology, Sydney (UTS), for their extended long-term support and especially to Professor Hung Nguyen and Professor Mary-Anne Williams for having offered me an International Research Scholarship (IRS). I would like to extend further my appreciation to the Vice Chancellor's Conference

Funding and FEIT Travel Funding committees for their generous financial support of my conference attendance. I also would like to thank Professor Bijan Samali for his continuous help and support throughout my candidature. His guidance always helped me to find the right way in different situations.

It is with immense appreciation that I acknowledge the support of Thales Australia for funding this project, particularly Mr. Arthur Ollett and Mr. Stephane Ibos for their valuable advices.

I would like to show my gratitude to Ms. Phyllis Agius and Mr. Craig Shuard, Research Administration Officers, for their dedicated assistance. They have helped me whenever I needed administrative and paper works assistance.

Moving toward more personal acknowledgments, I am indebted to my wonderful sisters, Farnoush and Golnoush and my closest friend Ms. Sara Aarabi for helping me get through the difficult times, and for all the emotional support, comradery, and caring they provided.

Last, but most important, is the dedication of this thesis to my dearest parents, Nasro-lah Masihpour and Ghamar Didehban, and my unexampled husband, Mehdi Farahi. I give my deepest expression of love and appreciation for the encouragement that my beloved Mehdi gave, and the sacrifices he made during the study. I would like to thank him for his understanding, sharing and endless love, which has always been a great source of motivation, inspiration and energy for me.

It is difficult to find a sounding word to describe my love for my parents, who bore me, raised me, supported me, taught me, and loved me. I would like to thank them for all what they have given to me. Their encouragement has meant so much to me during the pursuit of my PhD degree and the completion of this thesis.

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List of Abbreviations

3D	3 Dimensional
ACE	Array Centre Excitation
AEE	Array Edge Excitation
AF	Amplify and Forward
AM	Agbinya-Masihpour
AoA	Angle of Arrival
BAN	Body Area Network
BS	Base Station
CAE	Collinear Array Excitation
DF	Decode and Forward
DL	Downlink
DSSS	Direct-Sequence Spread Spectrum
EF	Estimation and Forward
EM	Electromagnetic
FFD	Full Function Device
HF	High Frequency
IrDa	Infrared Data Association
ISM	Industrial, Scientific and Medical
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IG-BAN	Interest Group-Body Area Network
ISO	International Organization for Standardization
LF	Low Frequency

LoS	Line of Sight
LT	Location Tracking
M/A	Master/Assistant
MAC	Medium Access Control
MAMI	Master/Assistant Magnetic Induction
MI	Magnetic Induction
MIC	Medical Information and Communication
MICT	Medical Information and Communication Technology
MMAC	Mobility adoptive collision free MAC
MR-BS	Multihop Relay-Base Station
MR-Cell	Multihop Relay-cell
MS-MAC	Mobility aware MAC for Sensor Networks
MST	Minimum Spanning Tree
NFMI	Near Field Magnetic Induction
NFMIC	Near Field Magnetic Induction Communications
NLoS	Non Line of Sight
NTP	Network Time Protocol
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PBS	Pairwise Broadcast Synchronization
PC	Personal Computer
PHY	Physical Layer
Q-Factor	Quality Factor
Ra	Relay Assistant
RBS	Reference Broadcast Synchronization
RF	Radio Frequency
RFID	Radio Frequency Identification
RFD	Reduced Function Device
Rm	Relay Master
RS	Relay Station

RSS	Received signal Strength
Rx	Receiver
SAR	Specific Absorption Rate
SINR	Signal to Interference Noise Ratio
SNR	Signal to Noise Ratio
SS	Subscriber's Station
S-TDMA	Self-Organized Time Division Multiple Access
SUI	Stanford University Interim
TC	Triangle Centroid
TDMA	Time Division Multiple Access
TDoA	Time Difference of Arrival
Tx	Transmitter
UHF	Ultra High Frequency
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UWB	Ultra Wide Band
WLAN	Wireless Local Area Network
WPSM	Warfighter Physiologic Status Monitoring
WiMAX	Worldwide Interoperability for Microwave Access